TRISTAR25 GPS Receiver Module
User's Guide

Manual Revision History

Revision	Date	Update Summary
Issue A	December 2002	Initial release
Issue B	February 2003	Add pins electrical characteristics

1 Introduction

1.1 Overview

The TISTAR25 GPS Receiver is intended for use in a wide range of applications. The receiver simultaneously tracks up to twelve satellites, provides accurate satellite positioning data with fast time-to-first-fix (TTFF) and low power consumption. It is designed for high performance and maximum flexibility in a wide range of applications including mobile asset tracking, in-vehicle automotive guidance, location sensing, telematics and so on. The highly integrated receiver achieves high performance, minimizes board size and power consumption requirements. The TISTAR25 is designed to withstand harsh operating environments; however, it should be used inside an enclosure as a part of the application product designed by the system integrator.

1.2 Features

The TISTAR25 GPS receiver offers following features:

- Twelve parallel tracking channels
- Fast TTFF and low power consumption
- Compact design suitable for applications requiring small space
- Differential correction using real-time RTCM SC-104 data
- On-board rechargeable battery sustained real-time clock and memory for fast satellite reacquisition during power-up
- High accuracy one-pulse-per-second output
- Upgradeable firmware using flash-based program memory
- Supports NMEA-0183 protocol
- Full navigation accuracy achievable with Standard Positioning Service
- Optimized for navigation in urban-canyon environments
- Automatic cold start with no user initialization required

2 Receiver Operation

Upon power up, after initial self-test has completed, the TISTAR25 will begin satellite acquisition and tracking process. Under normal open-sky condition, position-fix can be achieved within approximately 45 seconds (within 15 seconds if valid ephemeris data is already collected from recent use). After receiver position has been calculated, valid position, velocity and time information are transmitted through the on board serial interface.

The receiver uses the latest stored position, satellite data, and current RTC time to achieve rapid GPS signal acquisition and fast TTFF. If the receiver is transported over a large distance across the globe, cold-start automatic-locate sequence is invoked. The first position fix may take up to five minutes searching the sky for the GPS signal. The acquisition performance can be improved significantly if the host initializes the receiver with a rough estimate of time and user position.

As soon as GPS signal is acquired and tracked, the TISTAR25 will transmit valid navigation information through its serial interface. The navigation data contains following information:

- Receiver position in latitude, longitude, and altitude
- Receiver velocity
- Time
- DOP error-magnification factor
- GPS signal tracking status

The TISTAR25 will perform 3D navigation when four or more satellites are tracked. When three or fewer satellites are tracked, altitude-hold is enabled using the last computed altitude and 2D navigation mode is entered.

With signal blockage or rising and setting of the satellites, where a change in satellite constellation used for position fix occurred, large position error may result. The TISTAR25 incorporates a proprietary algorithm to compensate the effect of satellite constellation change, and maintains an accurate smooth estimate of the receiver’s position, velocity, and heading.

3 Hardware Interface

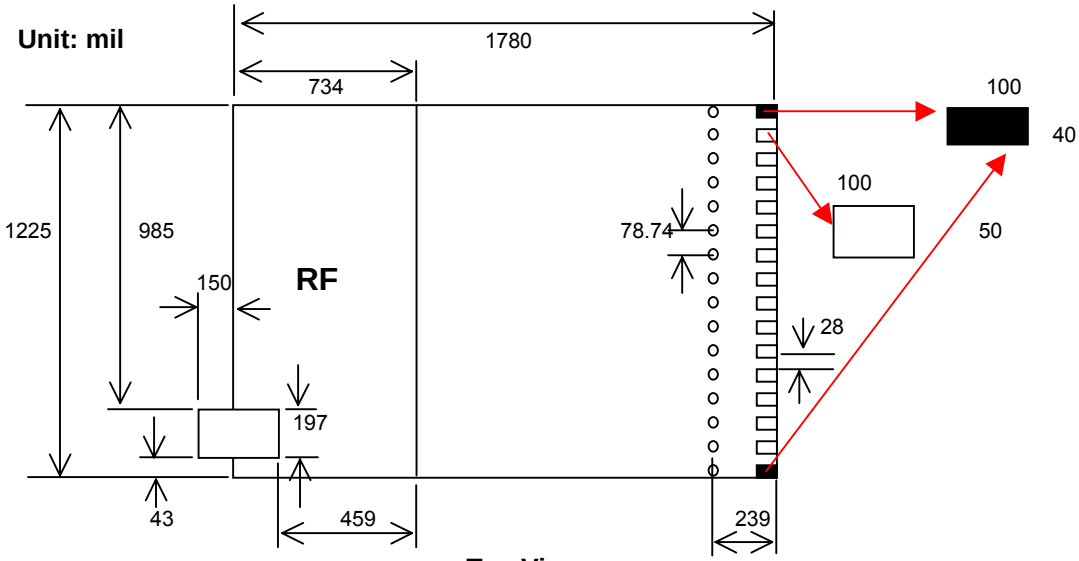
3.1 RF Connector

The RF connector is a 50 ohm straight MCX snap-on coaxial RF jack receptacle.

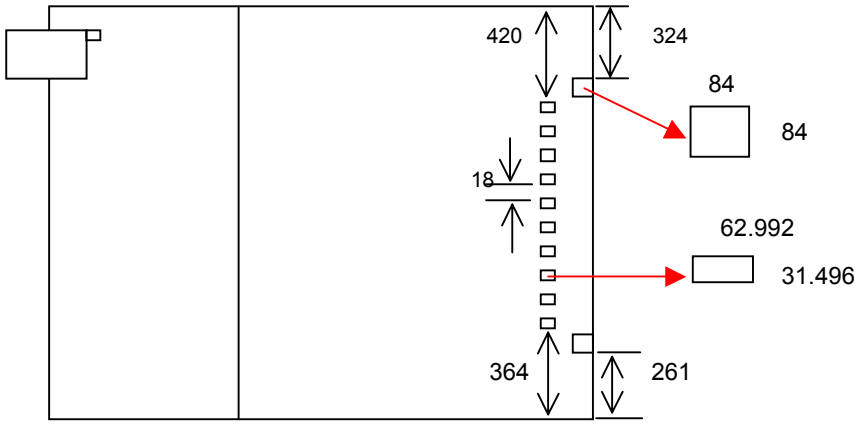
3.2 Interface Connector

There are three interface connectors, the first is a 10-pin Molex connector, the second is a 16-pin golden finger, and the third is a 16-pin header.

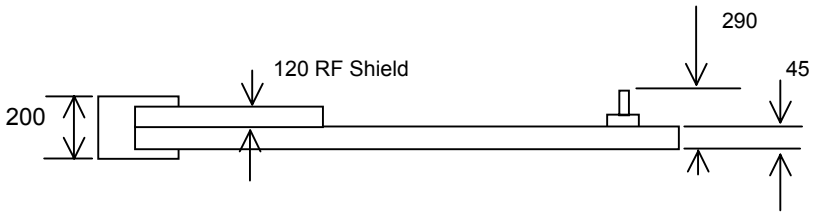
3.3 Mechanical Dimensions and Interface Connector



Top View



Bottom View



Lateral View

Figure 1

3.4 Interface Connector Pin Out

3.4.1 Molex Connector JP3

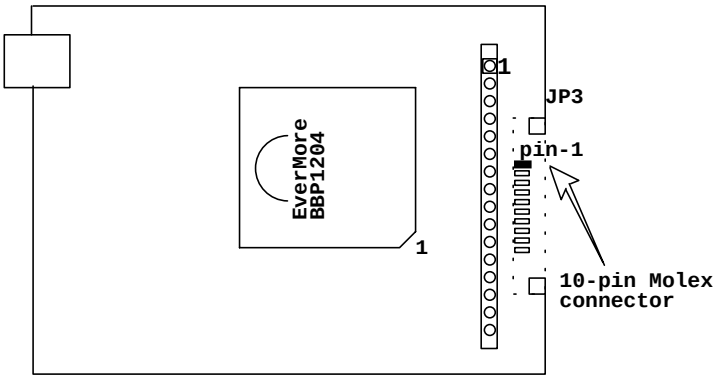


Figure 2

Pin	Function	Input/Output	Level	Pin	Function	Input/Output	Level
1	TXD0	Output	LVTTL	2	RXD0	Input	LVTTL
3	PWR_IN	Input	3.3V	4	GND	Ground	0V
5	LED0	In/Out	LVTTL	6	1PPS	Output	LVTTL
7	TXD1	Output	LVTTL	8	RXD1	Input	LVTTL
9	VBAT	Input	3.3V	10	ANT PWR	Input	

The following is a functional description of the pins on the 10-pin interface connector.

Pin 1. TXD0: Serial port output # 1 (GPS navigation output)

Pin 2. RXD0: Serial port input # 1 (command input)

Pin 3. PWR_IN: Power supply input, regulated 3.3V, 112mA

Pin 4. GND: Ground

Pin 5. LED0: Reserved I/O port 31 from CPU

Pin 6. 1PPS: 1-pulse-per-second output. Active high for approx. 1usec

Pin 7. TXD1: Serial port output #2 (currently unused)

Pin 8. RXD1: Serial port input #2 (DGPS input)

Pin 9. VBAT: External backup battery charging input

Pin 10. ANT PWR: External active antenna power input

3.4.2 Pin Header Connector JP2

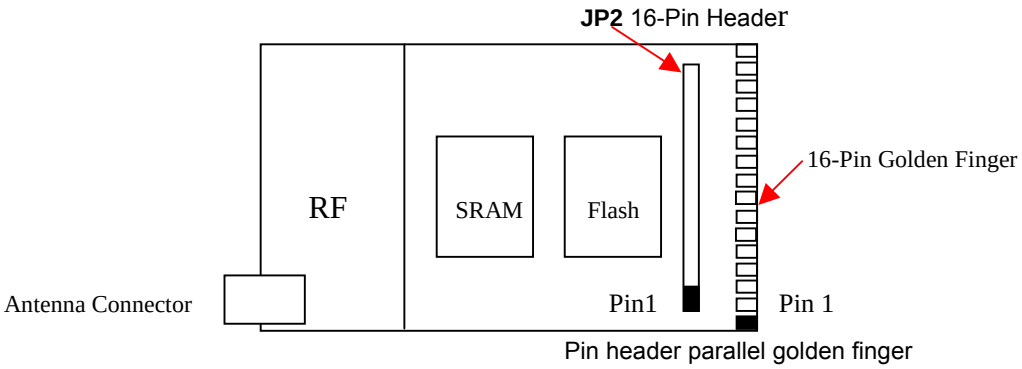


Figure 3

Pin	Function	Input/Output	Level	Pin	Function	Input/Output	Level
1	PIO1	In/Out	LVTTL	2	PIO10	In/Out	LVTTL
3	PIO11	In/Out	LVTTL	4	TXD0	Output	LVTTL
5	RXD0	Input	LVTTL	6	PWR_IN	Input	3.3V
7	GND	Ground	0V	8	LED0	In/Out	LVTTL
9	1PPS	Output	LVTTL	10	TXD1	Output	LVTTL
11	RXD1	Input	LVTTL	12	VBAT	Input	3.3V
13	ANT PWR	Input		14	PIO12	In/Out	LVTTL
15	PIO13	In/Out	LVTTL	16	PIO14	In/Out	LVTTL

The following is a functional description of the pins on the 16-pin interface connector.

Pin 1. PIO1: Reserved I/O port 1 from CPU

Pin 2. PIO10: Reserved I/O port 10 from CPU

Pin 3. PIO11: Reserved I/O port 11 from CPU

Pin 4. TXD0: Serial port output # 1 (GPS navigation output)

Pin 5. RXD0: Serial port input # 1 (command input)

Pin 6. PWR_IN: Power supply input, regulated 3.3V, 112mA

Pin 7. GND: Ground

Pin 8. LED0: Reserved I/O port 31 from CPU

Pin 9. 1PPS: 1-pulse-per-second output. Active high for approx. 1usec

Pin 10. TXD1: Serial port output #2 (currently unused)

Pin 11. RXD1: Serial port input #2 (DGPS input)

Pin 12. VBAT: External backup battery charging input

Pin 13. ANT PWR: External active antenna power input

Pin 14. PIO12: Either Reserved I/O port 12 from CPU or INT5

Pin 15. PIO13: Either Reserved I/O port 13 from CPU or INT6

Pin 16. PIO14: Reserved I/O port 14 from CPU

3.5 One-Pulse-Per-Second Output

The one-pulse-per-second output is provided for applications requiring precise timing measurements. The output pulse is 1usec in duration. The rising edge of the output pulse is accurate to +/-1usec with respect to the start of each GPS second. The accuracy of the one-pulse-per-second output is maintained only when the receiver has valid position fix.

3.6 RTCM Differential Data

By using differential GPS (DGPS) correction data in RTCM SC-104 format with message types of 1, 2, 3, and 9, position accuracy of less than 5 meters can be achieved. RXD1, pin-8 of the 10-pin Molex connector shown in figure 2, or pin-11of the 16-pin header shown in figure 3,is used as the DGPS input. Differential correction is applied automatically when the correction data is received at 9600baud.

4 SOFTWARE INTERFACE

This section describes the details of the serial port commands through which the TISTAR25 is controlled and monitored. The serial port commands allow users to set the receiver parameters, configure output message type, and retrieve status information. The baud rate and protocol of the host COM port must match the baud rate and protocol of the GPS receiver serial port for commands and data to be successfully transmitted and received. The default receiver protocol is 4800baud, 8 data bits, 1 stop bit, and none parity.

4.1 NMEA OUTPUT MESSAGE SPECIFICATION

The TISTAR25 supports NMEA-0183 output format as defined by the National Marine Electronics Association (http://www.nmea.org). The currently supported NMEA messages for GPS applications are:

GGA	Global Positioning System Fix Data
GLL	Geographic Position – Latitude / Longitude
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
RMC	Recommended Minimum Specific GNSS Data
VTG	Course Over Ground and Ground Speed

4.1.1 NMEA Checksum Calculation

The optional NMEA checksum can be enabled or disabled when setting up the NMEA protocol. The checksum consists of a “*” and two hexadecimal digits derived by exclusive-OR of all the characters between, but not including, the “$” and “*” characters.

4.1.2 GGA – Global Positioning System Fix Data

Purpose
Output time, position and position-fix related data.

Format
$GPGGA,hhmmss.sss,ddmm.mmmm,a,dddmm.mmmm,a,x,xx,xx.x,xxxxx.x,M,xx.x,M,xxx,xxxx*CS

Example
$GPGGA,083604.883,2446.5254,N,12100.1399,E,1,09,01.0,00155.7,M,16.3,M,,*6E

Output Rate

Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPGGA		GGA protocol header
2	UTC Time	083604.883		hhmmss.sss hour, minute, sec & decimal sec 000000.000 ~ 235959.999 Leading zeros transmitted
3	Latitude	2446.5254		ddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
4	N/S Hemisphere Indicator	N		a, N=north or S=south
5	Longitude	12100.1399		dddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
6	E/W Hemisphere Indicator	E		a, E=east or W=west
7	GPS Position Fix Indicator	1		x 0 = no position fix or invalid 1 = valid fix, SPS mode 2 = valid fix, DGPS, SPS mode
8	# of Satellites Used	09		xx, 00 ~ 12, Leading zeros transmitted
9	HDOP	01.0		xx.x, Leading zeros transmitted
10	MSL Altitude	00155.7	Meter	xxxxx.x MSL altitude = WGS-84 ellipsoid height minus geoidal separation. Currently this field is WGS-84 ellipsoid height Leading zeros transmitted
11	Unit of Altitude	M	Meter	
12	Geoid Separation	16.3		geoid separation
13	Unit of Geoid Separation	M	Meter	
14	Age of Differential GPS Data		second	xxx Time in seconds since last RTCM SC-104 Type-1 or Type-9 update. Null when DGPS is not used
15	Differential Reference Station ID			xxxx, 0000 ~ 1023 Leading zeros transmitted Null when DGPS is not used
16	Checksum	*6E		

4.1.3 GLL – Geographic Position – Latitude / Longitude

Purpose
Output latitude and longitude of current position, time, and status.

Format
$GPGLL,ddmm.mmmm,a,dddmm.mmmm,a,hhmmss.sss,x*CS

Example
$GPGLL,2446.5311,N,12100.1377,E,110519.259,A*35

Output Rate
Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPGLL		GLL protocol header
2	Latitude	2446.5311		ddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
3	N/S Hemisphere Indicator	N		a N=north or S=south
4	Longitude	12100.1377		dddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
5	E/W Hemisphere Indicator	E		a E=east or W=west
6	UTC Time	110519.259		hhmmss.sss hour, minute, sec & decimal sec 000000.000 ~ 235959.999 Leading zeros transmitted
7	Status	A		A=data valid V=data invalid
8	Checksum	*35		

4.1.4 GSA – GNSS DOP and Active Satellites

Purpose
Output operating mode, satellites used for navigation, and DOP values.

Format
$GPGSA,x,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx.x,xx.x,xx.x*CS

Example
$GPGSA,A,3,27,31,08,20,13,28,03,01,02,11,22,,01.3,00.8,01.0*0C

Output Rate
Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPGSA		GSA protocol header
2	Manual or Automatic Mode	A		x A=automatic, allowed to switch 2D/3D automatically M=manual, forced to operate in 2D or 3D mode
3	Navigation Solution Mode	3		x 1=fix unavailable 2=2D 3=3D
4	ID Numbers of the Satellites Used In Solution	27,31,08,20, 13,28,03,01, 02,11,22		xx SV ID of the satellites used for navigation Null for unused channels. Leading zeros transmitted
5	PDOP	01.3		xx.x Leading zeros transmitted
6	HDOP	00.8		xx.x Leading zeros transmitted
7	VDOP	01.0		xx.x Leading zeros transmitted
8	Checksum	*0C		

4.1.5 GSV – GNSS Satellites in View

Purpose
Output number of SVs in view, PRN numbers, elevation, azimuth and SNR values. Four satellites maximum per transmission, additional satellite data sent in the second or the third sentence.

Format
$GPGSV,x,x,xx,xx,xx,xxx,xx … xx,xx,xxx,xx*CS

Example
$GPGSV,3,1,11,27,59,276,44,31,50,046,44,08,38,309,44,20,07,165,39*70
$GPGSV,3,2,11,13,10,223,41,28,13,304,38,03,14,054,41,01,13,186,40*73
$GPGSV,3,3,11,02,06,303,43,11,73,165,43,22,06,113,35,,,,*48

Output Rate
Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPGSV		GSV protocol header
2	Total Messages	3		x, 1 ~ 3
3	Message Number	1		x, 1 ~ 3
4	Total Number of Satellites In View	11		xx, 0 ~ 12 Leading zeros transmitted
5	Satellite Number #1	27		xx, SV1 ID number, 01 ~ 32 Leading zeros transmitted
6	Elevation Angle #1	59	degree	xx, 00 ~ 90 Leading zeros transmitted
7	Azimuth Angle #1	276	degree	xxx, 000 ~ 359 Leading zeros transmitted
8	C/No #1	44	dB/Hz	xx, C/No 00 ~ 99 Leading zeros transmitted
9	Satellite Number #2	31		SV2 ID number, 01 ~ 32
10	Elevation Angle #2	50	degree	00 ~ 90
11	Azimuth Angle #2	046	degree	000 ~ 359
12	C/No #2	44	dB/Hz	C/No 00 ~ 99
13	Satellite Number #3	08		SV3 ID number , 01 ~ 32
14	Elevation Angle #3	38	degree	00 ~ 90
15	Azimuth Angle #3	309	degree	000 ~ 359
16	C/No #3	44	dB/Hz	C/No 00 ~ 99
17	Satellite Number #4	20		SV3 ID number, 01 ~ 32
18	Elevation Angle #4	07	degree	00 ~ 90
19	Azimuth Angle #4	165	degree	000 ~ 359
20	C/No #4	39	dB/Hz	C/No 00 ~ 99
21	Checksum	*70		

4.1.6 RMC – Recommended Minimum Specific GNSS Data

Purpose
Output time, date, position, course and speed data.

Format
$GPRMC,hhmmss.sss,x,ddmm.mmmm,a,dddmm.mmmm,a,xxx.x,xxx.x,ddmmyy,xxx.x,a*CS

Example
$GPRMC,083604.883,A,2446.5254,N,12100.1399,E,000.0,000.0,300502,003.3,W*76

Output Rate
Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPRMC		RMC protocol header
2	UTC time	083604.883		hhmmss.sss hour, minute, sec & decimal sec 000000.000 ~ 235959.999 Leading zeros transmitted
3	Status	A		x A=Data valid V=Navigation receiver warning
4	Latitude	2446.5254		ddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
5	N/S hemisphere indicator	N		a N=north or S=south
6	Longitude	12100.1399		dddmm.mmmm degree, minute & decimal minute Leading zeros transmitted
7	E/W hemisphere indicator	E		a E=east or W=west
8	Speed Over Ground	000.0	knot	xxx.x Leading zeros transmitted
9	Course Over Ground	000.0	degree	xxx.x Leading zeros transmitted
10	Date	300502		ddmmyy day, month, year (2 digit) Leading zeros transmitted
11	Magnetic variation	003.3	degree	00.0 to 359.9 degrees Leading zeros transmitted
12	Magnetic variation reference	W		a E=east or W=west Westerly variation adds to true course
13	Checksum	*76		

4.1.7 VTG – Course Over Ground and Ground Speed

Purpose
Outputs actual track made good and speed relative to the ground.

Format
$GPVTG,xxx.x,T,xxx.x,M,xxx.x,N,xxxx.x,K*CS

Example
$GPVTG,000.0,T,003.3,M,000.0,N,0000.0,K*7E

Output Rate
Programmable using EverMore Binary Message 0x8E and 0x8F.

Field	Name	Example	Unit	Description
1	Message ID	$GPVTG		VTG protocol header
2	Heading	000.0	degree	xxx.x Heading of the receiver when moving Leading zeros transmitted
3	True	T		Indicates true heading
4	Heading	003.3	degree	Degrees magnetic Magnetic course over ground, 000 to 359 Degrees Leading zeros transmitted
5	M	M		Indicates magnetic heading
6	Speed	000.0	knots	xxx.x Speed in knots Leading zeros transmitted
7	N	N		Indicates speed in knots
8	Speed	0000.0	Km/hr	xxxx.x Speed in km/hr Leading zeros transmitted
9	K	K		Indicates speed in km/hr
10	Checksum	*7E		

4.2 EVERMORE BINARY MESSAGE SPECIFICATION

The EverMore binary message protocol consists of 3 parts: message header, message body, and message footer.

Message Header		Message Body	Message Footer	
Start Sequence	Length of Message Body		Message Checksum	End Sequence
0x10 0x02	1 or 2 bytes	Up to 253 bytes	1 or 2 bytes	0x10 0x03

Message Header

The Message Header consists of 3 or 4 bytes:

Byte #1 - DLE = 0x10

Byte #2 - STX = 0x02

Byte #3 - Length of Message Body + 2

Byte #4 - when Byte #3 equals DLE (0x10), DLE (0x10) is sent out as the 4th byte of the message header; otherwise it is not sent.

Message Body

When DLE (0x10) is encountered in the message body, it is repeated. The EverMore Binary Message supports following message types for receiver configuration and status monitoring:

Binary Input Messages:

Message Type 0x80: Initialization
Message Type 0x81: Data Logging
Message Type 0x86: Set Elevation Mask
Message Type 0x87: Set DOP Mask
Message Type 0x8F: Operating Mode Configuration
Message Type 0x94: Differential GPS Control

Binary Output Messages:

Message Type 0x02: Navigation Data
Message Type 0x04: DOP Data
Message Type 0x06: Channel Status
Message Type 0x08: Measurement Data

Message Footer:

The Message Footer consists of 3 or 4 bytes:

Byte #1 - checksum of the Message Body (it is calculated by summing all bytes in the Message Body and taking the sum modulo 256)

Byte #2 - when Byte #1 equals DLE (0x10), DLE (0x10) is sent out as the 2nd byte of the message footer; otherwise it is not sent.

Byte #3 - DLE (0x10). If checksum is not 0x10, this DLE character becomes Byte #2

Byte #4 - ETX (0x03). If checksum is not 0x10, this ETX character becomes Byte #3

4.2.1 Binary Input Messages

4.2.1.1 EverMore Binary Input Message 0x80: Initialization

Purpose

Used to :

1. Set the initial time and position of the GPS receiver.
2. Select datum other than the default WGS-84.
3. Select the type of NMEA messages to output.
4. Enable or disable EverMore binary message output.
5. Change the baud rate configuration.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x80		Unsigned byte	
2 ~ 3	GPS week	0 ~ 65535	Unsigned 16bit integer	week
4 ~ 7	GPS tow	0 ~ 60479900	Unsigned 32bit integer	1/100 sec
8 ~ 9	Latitude	+/- 900	Signed 16bit integer	1/10 degree
10 ~ 11	Longitude	+/- 1800	Signed 16bit integer	1/10 degree
12 ~ 13	Altitude	-1000 ~ 18000	Signed 16bit integer	meter
14 ~ 15	Datum ID	0 ~ 65535	Unsigned 16bit integer	
16	Restart Mode (decimal) *0 = default mode* *1 = hot start* *2 = warm start* *3 = cold start* *4 = test start* *10 = datum input*		Unsigned byte	
17	NMEA Message Control Switch (1:ON, 0:OFF) *bit0 : GGA message on/off* *bit1 : GLL message on/off* *bit2 : GSA message on/off* *bit3 : GSV message on/off* *bit4 : RMC message on/off* *bit5 : VTG message on/off* *bit6 : Checksum on/off* EverMore Message Control Switch *bit7 : EverMore binary message on/off*			
18	Baud Rate Control *0 = 4800bps* *1 = 9600bps* *2 = 19200bps* *3 = 38400bps*			

See Appendix-A for Datum ID to use. When changing the Datum ID, Restart Mode field has to be set to 0x0A.

4.2.1.2 EverMore Binary Input Message 0x81: Data Logging

See section 4.3

4.2.1.3 EverMore Binary Input Message 0x86: Set Elevation Mask

Purpose
Set the elevation mask for position computation. Satellites with elevation angle less than the elevation mask angle will not be used for navigation solution.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x86		Unsigned byte	
2	Elevation Mask	0 ~ 89	Unsigned byte	degree
3 ~ 4	Reserved			

4.2.1.4 EverMore Binary Input Message 0x87: Set DOP Mask

Purpose

Set various DOP masks, which are used to set accuracy limits on position output. If the selected DOP mask is exceeded, new position-velocity-time solution is not calculated and last valid solution is output instead.

When DOP Select (byte #2) is set to Auto, navigation solution is in 3D mode when PDOP value is less than the PDOP Mask, navigation solution changes to 2D mode when PDOP value is greater than the PDOP Mask and HDOP value is less than the HDOP Mask, position data is flagged invalid when HDOP value is greater than the HDOP Mask.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x87		Unsigned byte	
2	DOP Select *0 = GDOP mask* *1 = Auto* *2 = PDOP mask* *3 = HDOP mask* *4 = Don't use mask*	0 ~ 4	Unsigned byte	
3	GDOP	1 ~ 99	Unsigned byte	
4	PDOP	1 ~ 99	Unsigned byte	
5	HDOP	1 ~ 99	Unsigned byte	
6 ~ 8	Reserved			

4.2.1.5 EverMore Binary Input Message 0x8F: Set Operating Mode

Purpose

Sets the navigation update rate and receiver-operating mode. The receiver-operating mode can be set to one of the following:

1. Normal full power mode without 1PPS output synchronized.
2. Power saving mode without 1PPS out synchronized.
3. Normal full-power mode with 1PPS output synchronized.

With Navigation Update Rate set to n, measurement is taken and navigation solution is computed every n seconds. When power saving mode is selected, the RF/GPSBBP On Time field is also referenced.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x8F		Unsigned byte	
2	Receiver Operating Mode *0 = Normal Mode* *1 = Power Saving* *2 = Normal Mode with 1PPS*	0 ~ 2	Unsigned byte	
3	Navigation Update Rate	1 ~ 10	Unsigned byte	1 / Hz
4	RF/GPSBBP On Time *0=Power on 160ms* *1=Power on 220ms* *2=Power on 280ms* *3=Power on 340ms* *4=Power on 400ms*	0 ~ 4	Unsigned byte	

Note: Instead of software control, the 1PPS function can be also enabled through hardware control. There are two I/O pins used for 1PPS function.

4.2.1.6 EverMore Binary Input Message 0x94: Differential GPS Control

Purpose
This command allows users to control the receiver's differential GPS capability.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x94		Unsigned byte	
2	Differential GPS Control *0 = disable* *1 = enable SBAS*	0 ~ 1	Unsigned byte	
3 ~ 4	Reserved	0	Unsigned 16bit integer	
5	Set the first SBAS satellite to be searched	0~5	Unsigned byte	
6 ~ 8	Reserved	0		

Note :

The relationship between the selected SBAS satellite and its PRN number is shown below.

SBAS id selected	SBAS
0	**WAAS POR (134)**
1	**WAAS AOR-W(122)**
2	**EGNOS AOR-E(120)**
3	**EGNOS IOR (131)**
4	**MTSAT-1 (129)**
5	**MTSAT-2 (137)**

4.2.2 Binary Output Messages

4.2.2.1 EverMore Binary Output Message 0x02: Navigation Data

Purpose

Output:

1 GPS time.
2 Receiver position and velocity in WGS-84 ECEF coordinate.
3 Number of visible satellites.
4 Number of satellites used in position-fix.
5 Firmware version.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x02		Unsigned byte	
2 ~ 3	GPS week	0 ~ 65535	Unsigned 16bit integer	week
4 ~ 7	GPS tow	0 ~ 60479900	Unsigned 32bit integer	1/100 sec
8 ~ 11	Position X	+/- 2^31	Signed 32bit integer	meter
12 ~ 15	Position Y	+/- 2^31	Signed 32bit integer	meter
16 ~ 19	Position Z	+/- 2^31	Signed 32bit integer	meter
20 ~ 21	Velocity X	+/- 2^15	Signed 16bit integer	1/10 m/sec
22 ~ 23	Velocity Y	+/- 2^15	Signed 16bit integer	1/10 m/sec
24 ~ 25	Velocity Z	+/- 2^15	Signed 16bit integer	1/10 m/sec
26 (bit0 ~ 3)	# of SV used	0 ~ 12	Unsigned 4bit integer	
26 (bit4 ~ 7)	# of SV visible	0 ~ 12	Unsigned 4bit integer	
27 ~ 28	Firmware version	0 ~ 65535	Unsigned 16bit integer	1/100

4.2.2.2 EverMore Binary Output Message 0x04: DOP Data

Purpose

Output:

1 GPS time.
2 GDOP, PDOP, HDOP, VDOP, and TDOP.
3 Receiver navigation mode.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x04		Unsigned byte	
2 ~ 3	GPS week	0 ~ 65535	Unsigned 16bit integer	week
4 ~ 7	GPS tow	0 ~ 60479900	Unsigned 32bit integer	1/100 sec
8	GDOP	0 ~ 255	Unsigned byte	0.1
9	PDOP	0 ~ 255	Unsigned byte	0.1
10	HDOP	0 ~ 255	Unsigned byte	0.1
11	VDOP	0 ~ 255	Unsigned byte	0.1
12	TDOP	0 ~ 255	Unsigned byte	0.1
13	Navigation Mode *0 = no position fix* *1 = 1D navigation* *2 = 2D navigation* *3 = 3D navigation* *4 = 3D navigation with DGPS*	0 ~ 4	Unsigned byte	

4.2.2.3 EverMore Binary Output Message 0x06: Channel Status

Purpose

Output:

1 GPS time.
2 Number of satellites in view.
3 Satellite ID, elevation angle, azimuth angle, C/N estimate, and status of the correlated channels. This set of data is sent for each in-view satellites.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x06		Unsigned byte	
2 ~ 3	GPS week	0 ~ 65535	Unsigned 16bit integer	week
4 ~ 7	GPS tow	0 ~ 60479900	Unsigned 32bit integer	1/100 sec
8	Number of SV in view	0 ~ 12	Unsigned byte	

Channel Data (7 bytes per channel). N=1,2,3,…n for the n visible satellites.

Byte #	Contents	Range	Size	Unit
7N+2	Channel	1 ~ 12	Unsigned byte	
7N+3	SV ID	1 ~ 32	Unsigned byte	
7N+4 ~7N+5	Azimuth	0 ~ 359	Unsigned byte	Degree
7N+6	Elevation	0 ~ 90	Unsigned byte	Degree
7N+7	C/N	0 ~ 99	Unsigned byte	dB/Hz
7N+8	Channel Status *bit0 = 1 satellite acquired* *bit1 = 1 code-tracking loop locked* *bit2 = 1 carrier-tracking loop locked* *bit3 = 1 data-bit synchronization done* *bit4 = 1 frame synchronization done* *bit5 = 1 ephemeris data collected* *bit6 = 1 used for position fix*			

Total length of message 0x06: 8 + 7 * Number Of Visible Satellites
Minimum length: 8 bytes (0 satellite visible)
Maximum length: 92 bytes (12 satellites visible)

4.2.2.4 EverMore Binary Output Message 0x08: Measurement Data

Purpose

Output:

1 GPS time.
2 Clock offset.
3 Numbers of satellites in view.
4 Satellite ID, elevation angle, channel status, pseudo-range, delta-range, and satellite Doppler frequency. This set of data is sent for each in-view satellites.

Format

Byte #	Contents	Range	Size	Scale Unit
1	Message ID = 0x08		Unsigned byte	
2 ~ 3	GPS week	0 ~ 65535	Unsigned 16bit integer	week
4 ~ 7	GPS tow	0 ~ 60479900	Unsigned 32bit integer	1/100 sec
8 ~ 9	Clock offset	0 ~ 65535	Unsigned 16bit integer	
10	Number of SV in view	0 ~ 12	Unsigned byte	

Channel Data (14 bytes per channel). Repeated for each in-view satellites.

Byte #	Contents	Range	Size	Unit
1 ~ 2	Channel SV Elevation	bit(0:3) 1 ~ 12 bit(4:8) 1 ~ 31 bit(9:15) 0 ~ 90	Unsigned byte Unsigned byte Unsigned byte	 Degree
3	Channel Status *bit0 = 1 satellite acquired* *bit1 = 1 code-tracking loop locked* *bit2 = 1 carrier-tracking loop locked* *bit3 = 1 data-bit synchronization done* *bit4 = 1 frame-synchronization done* *bit5 = 1 ephemeris data collected* *bit6 = 1 used for position fix*			
4	Reserved			
5 ~ 8	Pseudo-Range	+/- 2^31	Signed 32bit integer	Meter
9 ~ 12	Delta-Range	+/- 2^31	Signed 32bit integer	Meter/sec
13 ~ 14	Doppler	0 ~ 65535	Unsigned 16bit integer	Hz

Total length of message 0x08: 10 + 14 * Number Of Visible Satellites
Minimum length: 8 bytes (0 satellite in view)
Maximum length: 178 bytes (12 satellites in view)

4.3 Data Logging

In applications where the GPS receiver reported position, velocity, and time needs to be logged, the TISTAR25 supports logging capability directly by storing the data in the on-board memory. The logged data may be retrieved later.

The logged information consists of:

- GPS time (WNO, TOW), with 1 second resolution.
- Position in ECEF coordinate, with 1 meter resolution.
- Velocity, with 1 meter/sec resolution.
- Navigation mode (2D, 3D).
- DGPS used indicator

All data logging commands and each logged data output is sent with message header, message body, and message footer protocol as described in section 4.2.

The TISTAR25 can log up to 5000 sets of data.

4.3.1 Data Logging Input Messages

4.3.1.1 LogConfig Set

This command configures the logging function.

Byte #	Contents	Range	Size	Unit
1	Message ID = 0x81		Unsigned byte	
2	Command	LogConfig = 0x10	Unsigned byte	
3 ~ 4	Configuration	*1 = enable data logging* *0 = disable data logging*	Unsigned 16bit integer	
5 ~ 6	delta_Tmin	0 ~ 65535	Unsigned 16bit integer	sec
7 ~ 8	delta_Tmax	0 ~ 65535	Unsigned 16bit integer	sec
9 ~ 10	delta_D	0 ~ 65535	Unsigned 16bit integer	meter

The data logging function stores receiver position, velocity, time and status information according to the following algorithm:

delta_Tmin : Time interval to check if data logging is required; must be > 0.
delta_Tmax : Maximum time interval beyond which data must be logged.
delta_D : Maximum distance beyond which data must be logged.

distance = current_position – last_logged_position
elapsed_time = current_time – last_logged_time
if ((elapsed_time < (delta_Tmin - 1)) or (delta_Tmin == 0)) return and do not record PVT data
if (((elapsed_time > (delta_Tmax - 1)) and (delta_Tmax > 0))
or ((distance > (delta_D - 1)) and (delta_D > 0))) record PVT data

4.3.1.2 LogData Dump

This command configures the receiver to output all the logged data in NMEA-0183 format or binary format. Data logging is disabled upon reception of the command.

Byte #	Contents	Range	Size	Scale
1	Message ID = 0x81		Unsigned byte	
2	Command	LogDump = 0x12	Unsigned byte	
3	Baud Rate	*0 = 4800 bps* *1 = 9600 bps* *2 = 19200 bps* *3 = 38400 bps*		
4	Message Type	*bit0 = GGA message on/off (0:OFF, 1:ON)* *bit1 = GLL message on/off* *bit2 = RMC message on/off* *bit3 = VTG message on/off* *bit4~6 = reserved* *bit7 = Log binary data on/off*		

When bit7 of byte 4 is set, logged data is sent in binary format; otherwise it is sent in NMEA format. Bit0 ~ bit3 of byte 4 specifies which NMEA messages to be sent.

4.3.1.3 LogData Erase

This message commands the receiver to erase the logged data stored in the memory.

Byte #	Contents	Range	Size	Scale
1	Message ID = 0x81		Unsigned byte	
2	Command	LogEarse = 0x11	Unsigned byte	

4.3.1.4 LogConfig Read

This command retrieves the data logging configuration, and the information on percentage of the data buffer used. The logging configuration information is returned using private message 0x20, described in section 4.3.2.2.

Byte #	Contents	Range	Size	Scale
1	Message ID = 0x81		Unsigned byte	
2	Command	LogRead = 0x13	Unsigned byte	

4.3.2 Data Logging Output Messages

4.3.2.1 LogData

When the **LogData Dump** command is sent to the receiver to retrieve the logged data in binary format, each logged record is send out according to the format listed below with header and footer described in section 4.2 added. The logged data is output consecutively until all data stored in the on-board memory is sent out.

Byte #	Contents	Range	Size	Unit
1	Message ID = 0x22		Unsigned byte	
2 ~ 3	Velocity	mode[13] DGPS[12] velocity[9:0]	Unsigned 16bit integer	
4 ~ 7	GPS Time	GPS week [31: 20] GPS tow [19: 0]	Unsigned 16bit integer	
8 ~ 11	EFEC_X	+/- 2^31	Signed 32bit integer	meter
12 ~ 15	EFEX_Y	+/- 2^31	Signed 32bit integer	meter
16 ~ 19	EFEC_Z	+/- 2^31	Signed 32bit integer	meter

mode : Navigation mode (0=2D, 1=3D)
DGPS : 0 = no DGPS used, 1 = used DGPS correction
velocity[9:0] : velocity in m/s, range 0 ~ 1023
ECEF_X : ECEF coordinate X axis
ECEF_Y : ECEF coordinate Y axis
ECEF_Z : ECEF coordinate Z axis

4.3.2.2 LogConfig Info

When **LogConfig Read** or **LogConfig Set** command is sent to the receiver, data logging configuration and percentage of the data buffer usage are returned in the format shown below:

Byte #	Contents	Range	Size	Unit
1	Message ID = 0x20		Unsigned byte	
2 ~ 3	Buffer Used Percentage	0 ~ 10000	Unsigned 16bit integer	0.01%
4 ~ 5	Configuration	*1 = log data* *0 = stop logging data*	Unsigned 16bit integer	
6 ~ 7	delta_Tmin	0 ~ 65535	Unsigned 16bit integer	Sec
8 ~ 9	delta_Tmax	0 ~ 65535	Unsigned 16bit integer	Sec
10 ~ 11	delta_D	0 ~ 65535	Unsigned 16bit integer	meter

4.3.3 Data Logging Programming Description

4.3.3.1 Configuring for Data Logging

1. Send **LogConfig Set** command to the receiver to enable data logging.
2. The receiver will start logging data and return the **LogConfig Info** message three times. The logged receiver position-velocity-time data is stored in a circular buffer. When the buffer becomes full, oldest data is over-written.
3. The **LogConfig Read** command may be issued to request sending of **LogConfig Info** message again three times.

4.3.3.2 Retrieving Logged Data

1. Issue **LogData Dump** command to the receiver.
2. Upon reception of the **LogData Dump** command, the receiver disables data logging automatically and starts to output the logged data either in NMEA format or in binary **LogData** message format, according to the format requested in the previously issued **LogData Dump** command, until all logged data dumped.
3. Another issue of the **LogData Dump** command to the receiver will cause step 2 to be performed again; the same set of data will be dumped.
4. To continue data logging operation, send **LogConfig Set** command to the receiver again. Newly logged data will be placed right after the latest logged data in the circular buffer. If the **LogData Dump** command is issued and the data buffer is not used up yet, both the newly logged data and the previously logged data will be dumped. Note that **LogData Dump** command dumps everything in the data buffer.
5. To ensure only newly logged data is dumped after **LogConfig Set** command is issued, send **LogData Erase** command to clear the log buffer prior to sending the **LogConfig Set** command.

APPENDIX A SUPPORTED DATUM LIST

DATUM DESCRIPTION TABLE

Datumn ID	Datumn	dX	dY	dZ	Ellipsoid	Region of Use
0	WGS-84	0	0	0	WGS 84	Global
1	WGS-84	0	0	0	WGS84	Global
2	Adindan	-118	-14	218	Clarke 1880	Burkina Faso
3	Adindan	-134	-2	210	Clarke 1880	Cameroon
4	Adindan	-165	-11	206	Clarke 1880	Ethiopia
5	Adindan	-123	-20	220	Clarke 1880	Mali
6	Adindan	-166	-15	204	Clarke 1880	MEAN FOR Ethiopia; Sudan
7	Adindan	-128	-18	224	Clarke 1880	Senegal
8	Adindan	-161	-14	205	Clarke 1880	Sudan
9	Afgooye	-43	-163	45	Krassovsky 1940	Somalia
10	Ain el Abd 1970	-150	-250	-1	International 1924	Bahrain
11	Ain el Abd 1970	-143	-236	7	International 1924	Saudi Arabia
12	American Samoa 1962	-115	118	426	Clarke 1866	American Samoa Islands
13	Anna 1 Astro 1965	-491	-22	435	Australian National	Cocos Islands
14	Antigua Island Astro 1943	-270	13	62	Clarke 1880	Antigua (Leeward Islands)
15	Arc 1950	-138	-105	-289	Clarke 1880	Botswana
16	Arc 1950	-153	-5	-292	Clarke 1880	Burundi
17	Arc 1950	-125	-108	-295	Clarke 1880	Lesotho
18	Arc 1950	-161	-73	-317	Clarke 1880	Malawi
19	Arc 1950	-143	-90	-294	Clarke 1880	MEAN FOR Botswana; Lesotho; Malawi; Swaziland; Zaire; Zambia; Zimbabwe
20	Arc 1950	-134	-105	-295	Clarke 1880	Swaziland
21	Arc 1950	-169	-19	-278	Clarke 1880	Zaire
22	Arc 1950	-147	-74	-283	Clarke 1880	Zambia
23	Arc 1950	-142	-96	-293	Clarke 1880	Zimbabwe
24	Arc 1960	-160	-6	-302	Clarke 1880	MEAN FOR Kenya; Tanzania
25	Arc 1960	-157	-2	-299	Clarke 1880	Kenya
26	Arc 1960	-175	-23	-303	Clarke 1880	Taanzania
27	Ascension Island 1958	-205	107	53	International 1924	Ascension Island
28	Astro Beacon E 1945	145	75	-272	International 1924	Iwo Jima
29	Astro DOS 71/4	-320	550	-494	International 1924	St Helena Island
30	Astro Tern Island (FRIG) 1961	114	-116	-333	International 1924	Tern Island
31	Astronomical Station 1952	124	-234	-25	International 1924	Marcus Island
32	Australian Geodetic 1966	-133	-48	148	Australian National	Australia; Tasmania
33	Australian Geodetic 1984	-134	-48	149	Australian National	Australia; Tasmania
34	Ayabelle Lighthouse	-79	-129	145	Clarke 1880	Djibouti
35	Bellevue (IGN)	-127	-769	472	International 1924	Efate & Erromango Islands
36	Bermuda 1957	-73	213	296	Clarke 1866	Bermuda
37	Bissau	-173	253	27	International 1924	Guinea-Bissau
38	Bogota Observatory	307	304	-318	International 1924	Colombia
39	Bukit Rimpah	-384	664	-48	Bessel 1841	Indonesia (Bangka & Belitung Ids)

40	Camp Area Astro	-104	-129	239	International 1924	Antarctica (McMurdo Camp Area)
41	Campo Inchauspe	-148	136	90	International 1924	Argentina
42	Canton Astro 1966	298	-304	-375	International 1924	Phoenix Islands
43	Cape	-136	-108	-292	Clarke 1880	South Africa
44	Cape Canaveral	-2	151	181	Clarke 1866	Bahamas; Florida
45	Carthage	-263	6	431	Clarke 1880	Tunisia
46	Chatham Island Astro 1971	175	-38	113	International 1924	New Zealand (Chatham Island)
47	Chua Astro	-134	229	-29	International 1924	Paraguay
48	Corrego Alegre	-206	172	-6	International 1924	Brazil
49	Dabola	-83	37	124	Clarke 1880	Guinea
50	Deception Island	260	12	-147	Clarke 1880	Deception Island; Antarctia
51	Djakarta (Batavia)	-377	681	-50	Bessel 1841	Indonesia (Sumatra)
52	DOS 1968	230	-199	-752	International 1924	New Georgia Islands (Gizo Island)
53	Easter Island 1967	211	147	111	International 1924	Easter Island
54	Estonia; Coordinate System 1937	374	150	588	Bessel 1841	Estonia
55	European 1950	-104	-101	-140	International 1924	Cyprus
56	European 1950	-130	-117	-151	International 1924	Egypt
57	European 1950	-86	-96	-120	International 1924	England; Channel Islands; Scotland; Shetland Islands
58	European 1950	-86	-96	-120	International 1924	England; Ireland; Scotland; Shetland Islands
59	European 1950	-87	-95	-120	International 1924	Finland; Norway
60	European 1950	-84	-95	-130	International 1924	Greece
61	European 1950	-117	-132	-164	International 1924	Iran
62	European 1950	-97	-103	-120	International 1924	Italy (Sardinia)
63	European 1950	-97	-88	-135	International 1924	Italy (Sicily)
64	European 1950	-107	-88	-149	International 1924	Malta
65	European 1950	-87	-98	-121	International 1924	MEAN FOR Austria; Belgium; Denmark; Finland; France; W Germany; Gibraltar; Greece; Italy; Luxembourg; Netherlands; Norway; Portugal; Spain; Sweden; Switzerland
66	European 1950	-87	-96	-120	International 1924	MEAN FOR Austria; Denmark; France; W Germany; Netherlands; Switzerland
67	European 1950	-103	-106	-141	International 1924	MEAN FOR Iraq; Israel; Jordan; Lebanon; Kuwait; Saudi Arabia; Syria
68	European 1950	-84	-107	-120	International 1924	Portugal; Spain
69	European 1950	-112	-77	-145	International 1924	Tunisia
70	European 1979	-86	-98	-119	International 1924	MEAN FOR Austria; Finland; Netherlands; Norway; Spain; Sweden; Switzerland
71	Fort Thomas 1955	-7	215	225	Clarke 1880	Nevis; St. Kitts (Leeward Islands)

72	Gan 1970	-133	-321	50	International 1924	Republic of Maldives
73	Geodetic Datum 1949	84	-22	209	International 1924	New Zealand
74	Graciosa Base SW 1948	-104	167	-38	International 1924	Azores (Faial; Graciosa; Pico; Sao Jorge; Terceira)
75	Guam 1963	-100	-248	259	Clarke 1866	Guam
76	Gunung Segara	-403	684	41	Bessel 1841	Indonesia (Kalimantan)
77	GUX 1 Astro	252	-209	-751	International 1924	Guadalcanal Island
78	Herat North	-333	-222	114	International 1924	Afghanistan
79	Hermannskogel Datum	653	-212	449	Bessel 1841 (Namibia)	Croatia -Serbia, Bosnia-Herzegovina
80	Hjorsey 1955	-73	46	-86	International 1924	Iceland
81	Hong Kong 1963	-156	-271	-189	International 1924	Hong Kong
82	Hu-Tzu-Shan	-637	-549	-203	International 1924	Taiwan
83	Indian	282	726	254	Everest (India 1830)	Bangladesh
84	Indian	295	736	257	Everest (India 1956)	India; Nepal
85	Indian	283	682	231	Everest (Pakistan)	Pakistan
86	Indian 1954	217	823	299	Everest (India 1830)	Thailand
87	Indian 1960	182	915	344	Everest (India 1830)	Vietnam (Con Son Island)
88	Indian 1960	198	881	317	Everest (India 1830)	Vietnam (Near 16øN))
89	Indian 1975	210	814	289	Everest (India 1830)	Thailand
90	Indonesian 1974	-24	-15	5	Indonesian 1974	Indonesia
91	Ireland 1965	506	-122	611	Modified Airy	Ireland
92	ISTS 061 Astro 1968	-794	119	-298	International 1924	South Georgia Islands
93	ISTS 073 Astro 1969	208	-435	-229	International 1924	Diego Garcia
94	Johnston Island 1961	189	-79	-202	International 1924	Johnston Island
95	Kandawala	-97	787	86	Everest (India 1830)	Sri Lanka
96	Kerguelen Island 1949	145	-187	103	International 1924	Kerguelen Island
97	Kertau 1948	-11	851	5	Everest (Malay. & Sing)	West Malaysia & Singapore
98	Kusaie Astro 1951	647	1777	-1124	International 1924	Caroline Islands
99	Korean Geodetic System	0	0	0	GRS 80	South Korea
100	L. C. 5 Astro 1961	42	124	147	Clarke 1866	Cayman Brac Island
101	Leigon	-130	29	364	Clarke 1880	Ghana
102	Liberia 1964	-90	40	88	Clarke 1880	Liberia
103	Luzon	-133	-77	-51	Clarke 1866	Philippines (Excluding Mindanao)
104	Luzon	-133	-79	-72	Clarke 1866	Philippines (Mindanao)
105	M'Poraloko	-74	-130	42	Clarke 1880	Gabon
106	Mahe 1971	41	-220	-134	Clarke 1880	Mahe Island
107	Massawa	639	405	60	Bessel 1841	Ethiopia (Eritrea)
108	Merchich	31	146	47	Clarke 1880	Morocco
109	Midway Astro 1961	912	-58	1227	International 1924	Midway Islands
110	Minna	-81	-84	115	Clarke 1880	Cameroon
111	Minna	-92	-93	122	Clarke 1880	Nigeria
112	Montserrat Island Astro 1958	174	359	365	Clarke 1880	Montserrat (Leeward Islands)
113	Nahrwan	-247	-148	369	Clarke 1880	Oman (Masirah Island)
114	Nahrwan	-243	-192	477	Clarke 1880	Saudi Arabia
115	Nahrwan	-249	-156	381	Clarke 1880	United Arab Emirates
116	Naparima BWI	-10	375	165	International 1924	Trinidad & Tobago
117	North American 1927	-5	135	172	Clarke 1866	Alaska (Excluding Aleutian Ids)
118	North American 1927	-2	152	149	Clarke 1866	Alaska (Aleutian Ids East of 180øW)
119	North American 1927	2	204	105	Clarke 1866	Alaska (Aleutian Ids West of 180øW)

120	North American 1927	-4	154	178	Clarke 1866	Bahamas (Except San Salvador Id)
121	North American 1927	1	140	165	Clarke 1866	Bahamas (San Salvador Island)
122	North American 1927	-7	162	188	Clarke 1866	Canada (Alberta; British Columbia)
123	North American 1927	-9	157	184	Clarke 1866	Canada (Manitoba; Ontario)
124	North American 1927	-22	160	190	Clarke 1866	Canada (New Brunswick; Newfoundland; Nova Scotia; Quebec)
125	North American 1927	4	159	188	Clarke 1866	Canada (Northwest Territories; Saskatchewan)
126	North American 1927	-7	139	181	Clarke 1866	Canada (Yukon)
127	North American 1927	0	125	201	Clarke 1866	Canal Zone
128	North American 1927	-9	152	178	Clarke 1866	Cuba
129	North American 1927	11	114	195	Clarke 1866	Greenland (Hayes Peninsula)
130	North American 1927	-3	142	183	Clarke 1866	MEAN FOR Antigua; Barbados; Barbuda; Caicos Islands; Cuba; Dominican Republic; Grand Cayman; Jamaica; Turks Islands
131	North American 1927	0	125	194	Clarke 1866	MEAN FOR Belize; Costa Rica; El Salvador; Guatemala; Honduras; Nicaragua
132	North American 1927	-10	158	187	Clarke 1866	MEAN FOR Canada
133	North American 1927	-8	160	176	Clarke 1866	MEAN FOR CONUS
134	North American 1927	-9	161	179	Clarke 1866	MEAN FOR CONUS (East of Mississippi; River Including Louisiana; Missouri; Minnesota)
135	North American 1927	-8	159	175	Clarke 1866	MEAN FOR CONUS (West of Mississippi; River Excluding Louisiana; Minnesota; Missouri)
136	North American 1927	-12	130	190	Clarke 1866	Mexico
137	North American 1983	0	0	0	GRS 80	Alaska (Excluding Aleutian Ids)
138	North American 1983	-2	0	4	GRS 80	Aleutian Ids
139	North American 1983	0	0	0	GRS 80	Canada
140	North American 1983	0	0	0	GRS 80	CONUS
141	North American 1983	1	1	-1	GRS 80	Hawaii
142	North American 1983	0	0	0	GRS 80	Mexico; Central America
143	North Sahara 1959	-186	-93	310	Clarke 1880	Algeria
144	Observatorio Meteorologico 1939	-425	-169	81	International 1924	Azores (Corvo & Flores Islands)
145	Old Egyptian 1907	-130	110	-13	Helmert 1906	Egypt
146	Old Hawaiian	89	-279	-183	Clarke 1866	Hawaii
147	Old Hawaiian	45	-290	-172	Clarke 1866	Kauai
148	Old Hawaiian	65	-290	-190	Clarke 1866	Maui
149	Old Hawaiian	61	-285	-181	Clarke 1866	MEAN FOR Hawaii; Kauai; Maui; Oahu

150	Old Hawaiian	58	-283	-182	Clarke 1866	Oahu
151	Oman	-346	-1	224	Clarke 1880	Oman
152	Ordnance Survey Great Britain 1936	371	-112	434	Airy 1830	England
153	Ordnance Survey Great Britain 1936	371	-111	434	Airy 1830	England; Isle of Man; Wales
154	Ordnance Survey Great Britain 1936	375	-111	431	Airy 1830	MEAN FOR England; Isle of Man; Scotland; Shetland Islands; Wales
155	Ordnance Survey Great Britain 1936	384	-111	425	Airy 1830	Scotland; Shetland Islands
156	Ordnance Survey Great Britain 1936	370	-108	434	Airy 1830	Wales
157	Pico de las Nieves	-307	-92	127	International 1924	Canary Islands
158	Pitcairn Astro 1967	185	165	42	International 1924	Pitcairn Island
159	Point 58	-106	-129	165	Clarke 1880	MEAN FOR Burkina Faso & Niger
160	Pointe Noire 1948	-148	51	-291	Clarke 1880	Congo
161	Porto Santo 1936	-499	-249	314	International 1924	Porto Santo; Madeira Islands
162	Provisional South American 1956	-270	188	-388	International 1924	Bolivia
163	Provisional South American 1956	-270	183	-390	International 1924	Chile (Northern; Near 19 øS)
164	Provisional South American 1956	-305	243	-442	International 1924	Chile (Southern; Near 43 øS)
165	Provisional South American 1956	-282	169	-371	International 1924	Colombia
166	Provisional South American 1956	-278	171	-367	International 1924	Ecuador
167	Provisional South American 1956	-298	159	-369	International 1924	Guyana
168	Provisional South American 1956	-288	175	-376	International 1924	MEAN FOR Bolivia; Chile; Colombia; Ecuador; Guyana; Peru; Venezuela
169	Provisional South American 1956	-279	175	-379	International 1924	Peru
170	Provisional South American 1956	-295	173	-371	International 1924	Venezuela
171	Provisional South Chilean 1963	16	196	93	International 1924	Chile (Near 53 øS) (Hito XVIII)
172	Puerto Rico	11	72	-101	Clarke 1866	Puerto Rico; Virgin Islands
173	Pulkovo 1942	28	-130	-95	Krassovsky 1940	Russia
174	Qatar National	-128	-283	22	International 1924	Qatar
175	Qornoq	164	138	-189	International 1924	Greenland (South)
176	Reunion	94	-948	-1262	International 1924	Mascarene Islands
177	Rome 1940	-225	-65	9	International 1924	Italy (Sardinia)
178	S-42 (Pulkovo 1942)	28	-121	-77	Krassovsky 1940	Hungary
179	S-42 (Pulkovo 1942)	23	-124	-82	Krassovsky 1940	Poland
180	S-42 (Pulkovo 1942)	26	-121	-78	Krassovsky 1940	Czechoslavakia
181	S-42 (Pulkovo 1942)	24	-124	-82	Krassovsky 1940	Latvia
182	S-42 (Pulkovo 1942)	15	-130	-84	Krassovsky 1940	Kazakhstan
183	S-42 (Pulkovo 1942)	24	-130	-92	Krassovsky 1940	Albania
184	S-42 (Pulkovo 1942)	28	-121	-77	Krassovsky 1940	Romania
185	S-JTSK	589	76	480	Bessel 1841	Czechoslavakia (Prior 1 JAN 1993)
186	Santo (DOS) 1965	170	42	84	International 1924	Espirito Santo Island

187	Sao Braz	-203	141	53	International 1924	Azores (Sao Miguel; Santa Maria Ids)
188	Sapper Hill 1943	-355	21	72	International 1924	East Falkland Island
189	Schwarzeck	616	97	-251	Bessel 1841 (Namibia)	Namibia
190	Selvagem Grande 1938	-289	-124	60	International 1924	Salvage Islands
191	Sierra Leone 1960	-88	4	101	Clarke 1880	Sierra Leone
192	South American 1969	-62	-1	-37	South American 1969	Argentina
193	South American 1969,	-61	2	-48	South American 1969	Bolivia
194	South American 1969,	-60	-2	-41	South American 1969	Brazil
195	South American 1969,	-75	-1	-44	South American 1969	Chile
196	South American 1969,	-44	6	-36	South American 1969	Colombia
197	South American 1969,	-48	3	-44	South American 1969	Ecuador
198	South American 1969,	-47	26	-42	South American 1969	Ecuador (Baltra; Galapagos)
199	South American 1969,	-53	3	-47	South American 1969	Guyana
200	South American 1969,	-57	1	-41	South American 1969	MEAN FOR Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; Guyana; Paraguay; Peru; Trinidad & Tobago; Venezuela
201	South American 1969,	-61	2	-33	South American 1969	Paraguay
202	South American 1969,	-58	0	-44	South American 1969	Peru
203	South American 1969,	-45	12	-33	South American 1969	Trinidad & Tobago
204	South American 1969,	-45	8	-33	South American 1969	Venezuela
205	South Asia	7	-10	-26	Modified Fischer 1960	Singapore
206	Tananarive Observatory 1925	-189	-242	-91	International 1924	Madagascar
207	Timbalai 1948	-679	669	-48	Everest (Sabah Sarawak)	Brunei; E. Malaysia (Sabah Sarawak)
208	Tokyo	-148	507	685	Bessel 1841	Japan
209	Tokyo	-148	507	685	Bessel 1841	MEAN FOR Japan; South Korea; Okinawa
210	Tokyo	-158	507	676	Bessel 1841	Okinawa
211	Tokyo	-147	506	687	Bessel 1841	South Korea
212	Tristan Astro 1968	-632	438	-609	International 1924	Tristan da Cunha
213	Viti Levu 1916	51	391	-36	Clarke 1880	Fiji (Viti Levu Island)
214	Voirol 1960	-123	-206	219	Clarke 1880	Algeria
215	Wake Island Astro 1952	276	-57	149	International 1924	Wake Atoll
216	Wake-Eniwetok 1960	102	52	-38	Hough 1960	Marshall Islands
217	WGS 1972	0	0	0	WGS 72	Global Definition
218	Yacare	-155	171	37	International 1924	Uruguay
219	Zanderij	-265	120	-358	International 1924	Suriname

ELLIPSOID DESCRIPTION TABLE

Ellipsoid	Semi-major axis (a)	Inverse flattening (1/f)
Airy 1830	6377563.396	299.3249646
Modified Airy	6377340.189	299.3249646
Australian National	6378160	298.25
Bessel 1841 (Namibia)	6377483.865	299.1528128
Bessel 1841	6377397.155	299.1528128
Clarke 1866	6378206.4	294.9786982
Clarke 1880	6378249.145	293.465
Everest (India 1830)	6377276.345	300.8017
Everest (Sabah Sarawak)	6377298.556	300.8017
Everest (India 1956)	6377301.243	300.8017
Everest (Malaysia 1969)	6377295.664	300.8017
Everest (Malay. & Sing)	6377304.063	300.8017
Everest (Pakistan)	6377309.613	300.8017
Modified Fischer 1960	6378155	298.3
Helmert 1906	6378200	298.3
Hough 1960	6378270	297
Indonesian 1974	6378160	298.247
International 1924	6378388	297
Krassovsky 1940	6378245	298.3
GRS 80	6378137	298.257222101
South American 1969	6378160	298.25
WGS 72	6378135	298.26
WGS 84	6378137	298.257223563

APPENDIX B DEFAULT VALUES

The product has the following factory preset default values:

Datum:	001 (WGS-84)
NMEA Enable Switch :	GGA ON
	GLL OFF
	GSA ON
	GSV ON
	RMC ON
	VTG OFF
	Checksum ON
EMT Private Message:	OFF
Baud Rate :	4800 Baud
Elevation Mask:	5 degrees
DOP Mask:	DOP Select: Auto
	GDOP: 20
	PDOP: 15
	HDOP: 8
Receiver Operating Mode:	Normal Mode (without 1PPS)